International Conference on Food Price Volatility: Causes & Challenges

25 – 26 February Rabat

ON THE DETERMINANTS OF FOOD PRICE VOLATILITY

K. ANO SUJITHAN, **S. AVOUYI-DOVI** & L. KOLIAI

Motivation

- There is a large debate on the main determinants of food price volatility (supply and demand factors, financial factors, speculation etc.).
- The increase in nominal food prices impacts especially the poorest populations and raises the question on food security.
- Commodity prices volatility can impact the developed economies through real interest rates volatility, etc. (Fernandez-Villaverde *et al*., 2011).
- There is a need for policy-makers to understand food price dynamics.

OBJECTIVES

- To scrutinize the recent developments in soft commodity markets (prices, volatilities, etc.)
- To provide some relevant volatility measures
- To identify the main determinants of food price volatilities in a coherent framework
- To draw some policy issues

Our contribution

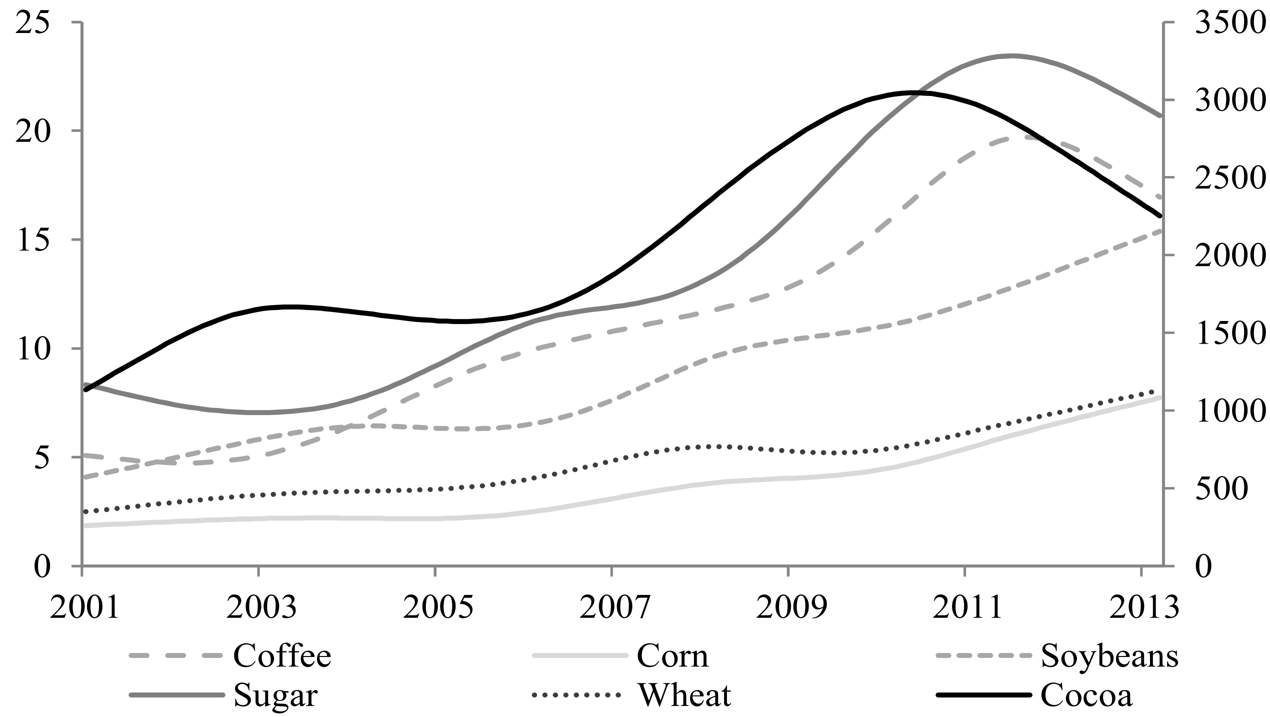
1. **Recent developments in food commodity markets**
   1) Price fluctuations
   2) Descriptive Statistics (volatility measures, dependence indices, …)
2. **Main determinants of food price volatility**
   1) The model
   2) The main results
   3) Robustness checks
3. **Policy issues**
4. **Conclusion**

Recent food commodity price swings

- The prices of most food commodities almost doubled between 2006 and July 2008.
- CRB foodstuff spot index rose by around 50% from 2007 to 2008.
- A Similar pattern was observed between mid-2010 and December 2011
- …but some discrepancies appeared between the two sub-periods on individual levels.

Recent food commodity price swings

- Food commodities prices trends (Hodrick Prescott filter) confirmed this observation.



Sources: Datastream and authors' calculations.

RECENT FOOD COMMODITY PRICE SWINGS

- In this study, we focus on six soft commodities: cocoa, coffee, corn, soybeans, sugar and wheat.
  - Coffee is one of the most traded food commodities.
  - Cocoa is the largest resource for some developing countries, especially in Africa.
  - Grains are the major staple food, especially in developing countries. They are also considered as animal feedstock and can be used as “currency”.
  - Rice is excluded from our framework due to its difference in terms of production, trade and consumption.

FOOD PRICE VOLATILITY MEASUREMENT

- Volatility plays a key role in finance and economics.
- To measure food price volatility, several options are available:
  - statistics Standard dispersion indicators (standard deviation (SD), the inter-quartile ratio (IQR), the mean absolute deviation (MAD), etc.).
  - volatility from GARCH or stochastic volatility framework or from nonparametric based on high-frequency
- In this presentation we are focusing on standard dispersion indicators.

FOOD PRICE VOLATILITY MEASUREMENT

- We computed SD, IQR and MAD on a 3M / 6M / 12M-rolling basis for all commodities.
- 3-month, 6-month and 12-month rolling measures display similar patterns for each commodity and the correlations are pretty high, whatever the rolling-window.

FOOD PRICE VOLATILITY MEASUREMENT

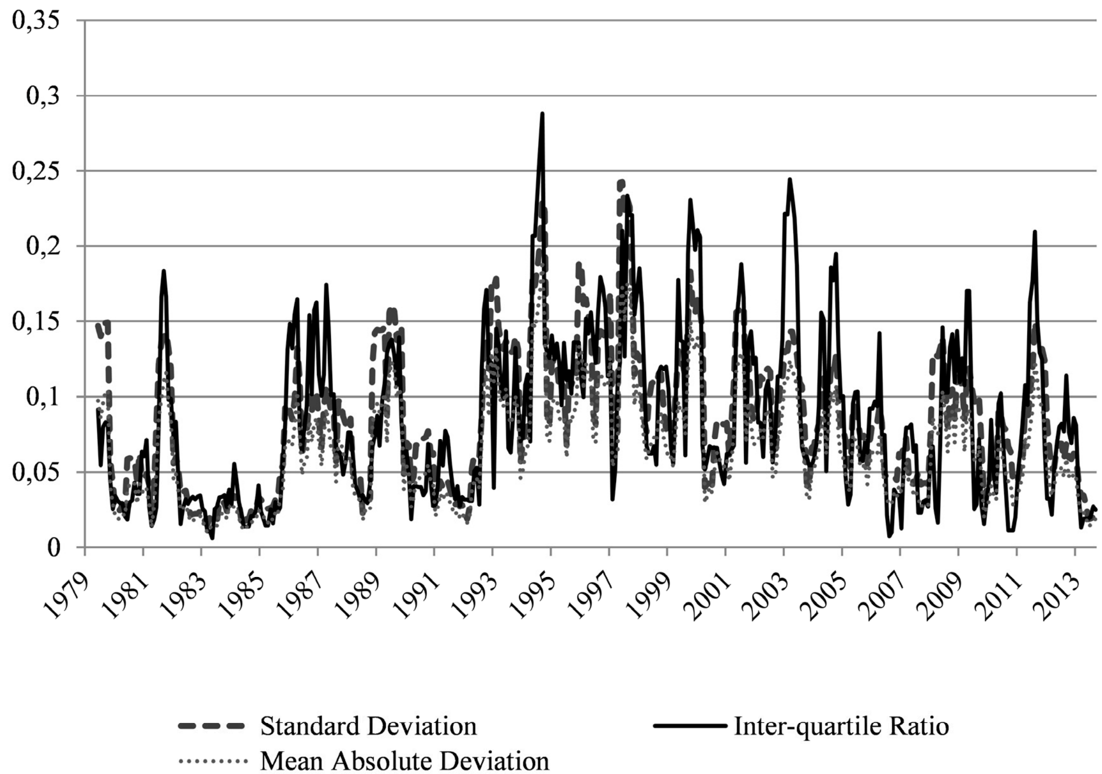
- We also observed a strong dependence structure of food volatility measures.

		Cocoa		Coffee		Corn		Soybeans		Sugar		Wheat	
		IQR	MAD	IQR	MAD	IQR	MAD	IQR	MAD	IQR	MAD	IQR	MAD
Full sample	SD	0.75 (0.58) [0.77]	0.97 (0.87) [0.98]	0.73 (0.54) [0.72]	0.97 (0.87) [0.97]	0.81 (0.63) [0.83]	0.98 (0.90) [0.98]	0.77 (0.51) [0.67]	0.98 (0.89) [0.98]	0.84 (0.67) [0.83]	0.98 (0.89) [0.97]	0.84 (0.54) [0.71]	0.98 (0.85) [0.96]
	IQR	-	0.87 (0.70) [0.88]	-	0.87 (0.66) [0.84]	-	0.89 (0.72) [0.90]	-	0.87 (0.60) [0.77]	-	0.92 (0.76) [0.91]	-	0.91 (0.67) [0.84]
2001-2006	SD	0.74 (0.59) [0.80]	0.97 (0.88) [0.98]	0.80 (0.62) [0.81]	0.98 (0.89) [0.98]	0.86 (0.66) [0.84]	0.98 (0.91) [0.98]	0.85 (0.50) [0.65]	0.99 (0.88) [0.98]	0.79 (0.68) [0.82]	0.97 (0.88) [0.97]	0.41 (0.28) [0.40]	0.93 (0.74) [0.90]
	IQR	-	0.87 (0.71) [0.88]	-	0.90 (0.72) [0.89]	-	0.92 (0.74) [0.90]	-	0.92 (0.60) [0.76]	-	0.90 (0.77) [0.91]	-	0.68 (0.50) [0.66]
2007- Mar. 2013	SD	0.75 (0.59) [0.78]	0.81 (0.86) [0.96]	0.63 (0.45) [0.60]	0.96 (0.85) [0.97]	0.73 (0.54) [0.72]	0.98 (0.88) [0.97]	0.63 (0.44) [0.60]	0.97 (0.89) [0.98]	0.88 (0.71) [0.86]	0.99 (0.92) [0.99]	0.84 (0.62) [0.80]	0.98 (0.86) [0.96]
	IQR	-	0.89 (0.71) [0.89]	-	0.81 (0.58) [0.76]	-	0.84 (0.65) [0.84]	-	0.78 (0.55) [0.71]	-	0.93 (0.76) [0.91]	-	0.92 (0.75) [0.91]

Linear correlations are given in the 1st line. Kendall's tau and Spearman's rho values are displayed in brackets and square brackets, respectively.

FOOD PRICE VOLATILITY MEASUREMENT

- An example with coffee:



- The 6-M rolling standard deviation is used in the benchmark model.

The model

- We use a dynamic multivariate framework: the vector autoregressive (VAR) model (Sims, 1980).
- Let y_t be the $1 \times M$ vector of endogenous variables, the $VAR(p)$model is an p^{th} order autoregression of y, of the form:

$$A(\mathrm{L})\, y_t = c + \varepsilon_t \quad \text{for } t = 1, \ldots, T,$$

  - T is the sample size, $A(\mathrm{L})$ is a polynomial matrix in the lag operator L of order p and ε_t a vector of error terms i.i.d.$\mathcal{N}_M(0_M, \Sigma)$.
- The likelihood function can be derived from the sampling density $\mathbb{P}\mathrm{r}\,(y|\alpha, \Sigma)$, where $\alpha = vec(A)$.

The model

- Several potential drivers of the food prices volatilities are tested in the model.
- The benchmark framework is based on the following variables:
  - Food price (Gilbert 2010; Gilbert and Morgan 2010)
  - Biofuel prices (Gilbert and Morgan 2010; Busse *et al*., 2010)
  - WTI Crude Oil price (Nazlioglu *et al*., 2013; Du *et al*., 2011)
  - S&P 500 (Mensi *et al*., 2013; Creti *et al*., 2013)
  - US IPI (Gilbert and Morgan 2010)
- In order to take into account of the stationary hypothesis, only the differences of variables are introduced in the model.

WHICH MODEL AND ESTIMATION METHOD?

- To overcome the identification problem in the VAR framework some specific versions of the VAR are examined.
- Two approaches:
  - Reducing the number of parameters via SVAR models –but they require strong underlying theoretical backgrounds.
  - Introducing Bayesian prior information in the VAR framework
- BVAR approach is our first best as it does not require judgmental adjustments. In addition, it can be easily used for forecasts, IFR's and structural analyses (Banbura *et al.,* 2010).
- BVAR model is estimated using the Minnesota prior (benchmark model)
  - Because it is simple to implement.
  - However, the performance of the Minnesota prior can be questionable if forecasts are made.

What conclusions can we arrive at from these empirical results?

- The analysis leads to the following remarks:
  - The volatilities of the different food commodities are influenced positively by their past values.
  - Food volatilities are positively impacted by the changes in the corresponding prices (first lag) and negatively (second lag) except for sugar. Price changes negatively influence wheat volatility (both lags).
  - US IPI has a negative impact on food price volatility.
  - The effect of biofuel price on corn and sugar is negative and positive on coffee and wheat.
  - The crude oil prices positively impacts cocoa, soybeans and sugar volatilities while wheat volatilities are negatively connected.
  - The S&P 500 is strongly correlated to the food commodities with a positive influence on wheat volatility and negative impact on cocoa. The results are more ambiguous for the other commodities.

OUR RESULTS

- Apart from the analysis of estimated coefficients, it is interesting to focus on the IRFs.

Shock	Expected impact of food Volatility	Our results
Price return	Uncertain (Gilbert 2010 ; Gilbert and Morgan 2010)	Negative (coffee, corn, soybeans, wheat) Positive (cocoa, sugar)
Biofuel price	Positive (Gilbert and Morgan 2010 ; Busse et al., 2010)	Negative (cocoa, coffee, soybeans, sugar) Positive (corn, wheat)
Oil price	Positive (Nazlioglu et al., 2013 ; Du et al., 2011)	Negative (soybeans, sugar) Positive (cocoa, coffee, corn, wheat)
Financial markets	Positive (Mensi et al., 2013 ; Creti et al., 2013)	Positive (except for sugar)
Real activity	Uncertain (Gilbert and Morgan 2010)	Negative (except for corn)

Robustness checks

- We made some additional regressions for robustness checks:
  - To introduce alternative variables (Brent instead of WTI, MSCI World instead of S&P 500, Global GDP from the IMF instead of US IPI and IQRs instead of SDs).
  - To test for volatility spillovers in a BVAR framework including only the various food volatilities.
  - And last, to use another prior distribution (Normal-Wishart prior distribution).
- Overall, (i) the estimated coefficients remain steady with alternative variables, (ii) there are no volatility spillovers effects and (iii) Minnesota-based priors lead to clearer results.

Policy Issues

- Food price volatility can affect the current account and the nominal exchange rates.
- Food price volatility can also impact the CPI.
- The effects are country-dependent (dependence on food trade, weight of food in the CPI, etc.).
- To address these policy issues, we estimated BVAR models including main foods (corn, soybeans and wheat) price volatilities, industrial production index (IPI) and consumer price index.
- Due to data availability we only focused on 3 emerging countries (Brazil, Russia & South Africa) and 2 developed economies (the US & the euro area).

Policy Issues - Results

- The IRFs are mainly significant regarding IPIs and lead to the following conclusions:
  - A corn volatility shock drives down IPI for all countries except Brazil (the largest ethanol producer).
  - The reaction of IPI following a soybeans volatility shock is almost negligible for all countries except the US.
  - As for the other grains, a wheat volatility shock leads to a small decrease in IPI for the euro area, Brazil, Russia and South Africa.
- Grain volatility shocks have a negative impact on IPIs for all countries, except the US.
- Grain volatility shocks have no significant impact on CPIs.

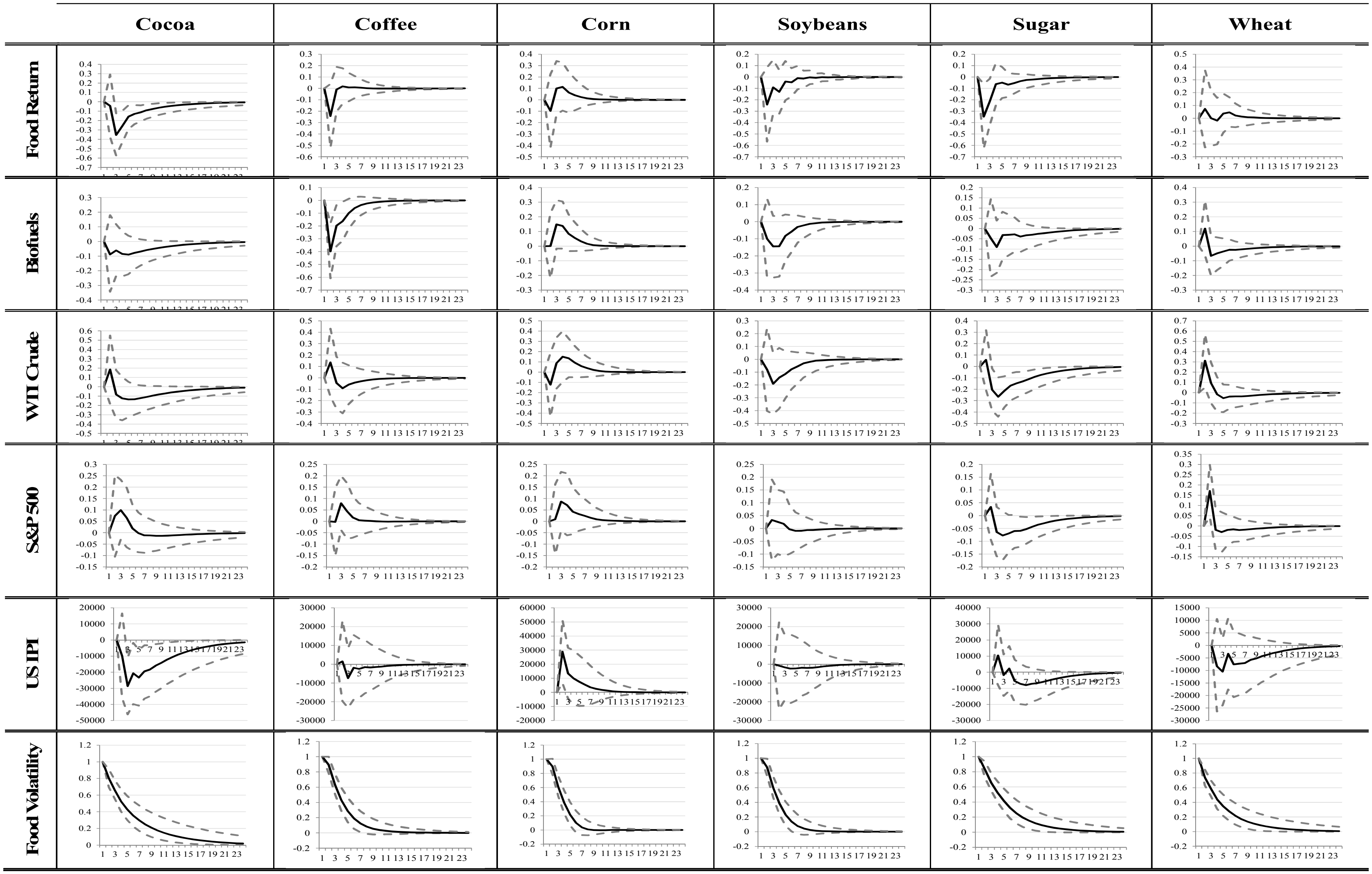
CONCLUSION

- Volatilities of the soft commodities are influenced by the price of commodities themselves, US IPI, biofuel price, oil prices and financial assets prices.
- The analysis of IRFs shows that:
  - A shock on price diminishes volatility for food commodities with the exception of corn and wheat.
  - Food volatility decreases after a biofuel price shock, with exception of soybeans and sugar.
  - Financial markets shock leads to high volatilities.
  - A US IPI shock negatively impacts food prices volatilities with exception with corn and sugar.
- Robustness checks confirm the relevance of the benchmark model.

Thank you

for your attention

Appendix 1 – IRFs from BVARs



Appendix 2a – BVAR Estimates Cocoa

	Cocoa Return	Biofuel	WTI Crude	S&P 500	US IPI	Cocoa Volatility
Price Return-1	-0.158	-0.024	-0.013	-0.074	-0.002	0.039
	(0.094)	(0.074)	(0.102)	(0.05)	(0.008)	(0.031)
	[-0.277;-0.038]	[-0.119;0.069]	[-0.144;0.117]	[-0.137;-0.01]	[-0.012;0.008]	[-0.001;0.078]
Biofuel-1	-0.057	0.040	0.153	-0.074	0.002	0.021
	(0.125)	(0.098)	(0.135)	(0.066)	(0.011)	(0.04)
	[-0.217;0.104]	[-0.087;0.165]	[-0.022;0.325]	[-0.157;0.009]	[-0.012;0.015]	[-0.03;0.071]
WTI Crude-1	-0.008	-0.040	0.099	-0.001	0.001	0.011
	(0.087)	(0.068)	(0.095)	(0.047)	(0.007)	(0.028)
	[-0.119;0.102]	[-0.128;0.047]	[-0.023;0.222]	[-0.062;0.06]	[-0.009;0.01]	[-0.026;0.047]
S&P 500-1	-0.101	-0.025	0.419	0.207	0.004	-0.057
	(0.177)	(0.141)	(0.195)	(0.096)	(0.015)	(0.058)
	[-0.33;0.123]	[-0.206;0.155]	[0.167;0.67]	[0.085;0.331]	[-0.015;0.024]	[-0.132;0.018]
US IPI-1	0.666	1.201	1.754	1.365	0.112	0.038
	(0.991)	(0.785)	(1.099)	(0.536)	(0.084)	(0.323)
	[-0.589;1.946]	[0.197;2.207]	[0.328;3.166]	[0.677;2.054]	[0.004;0.219]	[-0.378;0.447]
Volatility-1	-0.043	-0.086	0.184	0.072	-0.010	0.801
	(0.259)	(0.204)	(0.283)	(0.14)	(0.022)	(0.085)
	[-0.375;0.291]	[-0.344;0.179]	[-0.186;0.547]	[-0.107;0.252]	[-0.038;0.018]	[0.693;0.909]
Price Return-2	-0.074	-0.003	0.083	-0.026	0.006	-0.019
	(0.091)	(0.073)	(0.101)	(0.049)	(0.008)	(0.03)
	[-0.191;0.042]	[-0.096;0.091]	[-0.046;0.213]	[-0.089;0.038]	[-0.004;0.016]	[-0.057;0.02]
Biofuel-2	0.041	0.047	0.065	0.046	-0.016	-0.022
	(0.121)	(0.095)	(0.132)	(0.065)	(0.01)	(0.039)
	[-0.114;0.194]	[-0.076;0.169]	[-0.103;0.236]	[-0.037;0.129]	[-0.029;-0.003]	[-0.072;0.029]
WTI Crude-2	-0.134	-0.005	-0.082	0.052	0.011	0.022
	(0.081)	(0.065)	(0.089)	(0.043)	(0.007)	(0.026)
	[-0.24;-0.03]	[-0.089;0.077]	[-0.195;0.032]	[-0.003;0.107]	[0.002;0.02]	[-0.012;0.056]
S&P 500-2	0.171	-0.059	0.105	-0.156	0.039	-0.043
	(0.17)	(0.135)	(0.188)	(0.092)	(0.015)	(0.056)
	[-0.049;0.386]	[-0.234;0.116]	[-0.133;0.347]	[-0.274;-0.037]	[0.021;0.058]	[-0.115;0.029]
US IPI-2	0.312	1.139	0.532	1.001	0.187	-0.477
	(0.991)	(0.794)	(1.088)	(0.538)	(0.084)	(0.328)
	[-0.979;1.589]	[0.129;2.149]	[-0.866;1.921]	[0.318;1.701]	[0.078;0.297]	[-0.899;-0.056]
Volatility-2	-0.315	0.029	-0.254	0.029	-0.021	0.019
	(0.26)	(0.21)	(0.284)	(0.142)	(0.022)	(0.085)
	[-0.647;0.02]	[-0.239;0.3]	[-0.614;0.113]	[-0.151;0.212]	[-0.05;0.007]	[-0.089;0.128]
Intercept	0.040	0.013	0.011	-0.009	0.003	0.016
	(0.017)	(0.014)	(0.019)	(0.009)	(0.002)	(0.006)
	[0.017;0.062]	[-0.005;0.03]	[-0.014;0.036]	[-0.021;0.003]	[0.001;0.005]	[0.009;0.023]

Appendix 2b – BVAR Estimates Coffee

	Coffee Return	Biofuel	WTI Crude	S&P 500	US IPI	Coffee Volatility
Price Return-1	-0.166	-0.077	-0.032	-0.038	-0.001	-0.006
	(0.086)	(0.067)	(0.092)	(0.045)	(0.007)	(0.033)
	[-0.275;-0.056]	[-0.163;0.008]	[-0.149;0.085]	[-0.095;0.02]	[-0.01;0.009]	[-0.048;0.037]
Biofuel-1	0.104	0.024	0.163	-0.091	0.003	0.056
	(0.128)	(0.099)	(0.137)	(0.067)	(0.011)	(0.049)
	[-0.06;0.27]	[-0.104;0.15]	[-0.015;0.336]	[-0.175;-0.005]	[-0.011;0.016]	[-0.006;0.118]
WTI Crude-1	-0.065	-0.035	0.100	-0.014	0.001	0.026
	(0.087)	(0.067)	(0.094)	(0.046)	(0.007)	(0.033)
	[-0.176;0.045]	[-0.122;0.052]	[-0.02;0.222]	[-0.074;0.045]	[-0.008;0.01]	[-0.017;0.069]
S&P 500-1	0.053	0.000	0.414	0.253	0.000	-0.093
	(0.182)	(0.142)	(0.196)	(0.097)	(0.015)	(0.071)
	[-0.182;0.283]	[-0.18;0.183]	[0.159;0.667]	[0.13;0.377]	[-0.019;0.02]	[-0.184;-0.002]
US IPI-1	1.464	1.173	1.929	1.382	0.152	-0.013
	(0.993)	(0.772)	(1.08)	(0.527)	(0.083)	(0.382)
	[0.206;2.761]	[0.179;2.158]	[0.55;3.325]	[0.704;2.054]	[0.045;0.258]	[-0.507;0.477]
Volatility-1	-0.238	-0.395	0.138	-0.002	0.001	0.893
	(0.217)	(0.168)	(0.233)	(0.115)	(0.018)	(0.084)
	[-0.516;0.042]	[-0.607;-0.177]	[-0.162;0.435]	[-0.149;0.147]	[-0.022;0.025]	[0.786;1]
Price Return-2	0.074	0.104	-0.009	0.027	0.001	-0.092
	(0.084)	(0.067)	(0.091)	(0.044)	(0.007)	(0.033)
	[-0.034;0.181]	[0.019;0.189]	[-0.126;0.109]	[-0.03;0.084]	[-0.008;0.011]	[-0.134;-0.049]
Biofuel-2	-0.034	0.013	0.105	0.042	-0.013	0.003
	(0.124)	(0.096)	(0.133)	(0.066)	(0.01)	(0.047)
	[-0.193;0.124]	[-0.111;0.135]	[-0.065;0.275]	[-0.043;0.127]	[-0.026;0]	[-0.057;0.064]
WTI Crude-2	0.059	-0.014	-0.070	0.046	0.012	-0.028
	(0.082)	(0.064)	(0.088)	(0.043)	(0.007)	(0.032)
	[-0.047;0.165]	[-0.096;0.069]	[-0.182;0.044]	[-0.009;0.101]	[0.003;0.021]	[-0.069;0.012]
S&P 500-2	-0.035	-0.142	0.092	-0.160	0.037	0.063
	(0.176)	(0.137)	(0.19)	(0.093)	(0.015)	(0.068)
	[-0.261;0.188]	[-0.316;0.032]	[-0.149;0.335]	[-0.28;-0.041]	[0.018;0.055]	[-0.023;0.15]
US IPI-2	0.774	0.935	0.593	0.829	0.213	-0.559
	(0.993)	(0.783)	(1.078)	(0.531)	(0.084)	(0.389)
	[-0.503;2.04]	[-0.069;1.936]	[-0.792;1.993]	[0.152;1.514]	[0.105;0.32]	[-1.056;-0.057]
Volatility-2	0.217	0.148	-0.128	0.036	-0.009	-0.148
	(0.216)	(0.171)	(0.232)	(0.116)	(0.018)	(0.084)
	[-0.059;0.491]	[-0.07;0.369]	[-0.421;0.17]	[-0.11;0.185]	[-0.032;0.015]	[-0.255;-0.04]
Intercept	0.005	0.030	0.003	-0.003	0.001	0.023
	(0.016)	(0.012)	(0.017)	(0.008)	(0.001)	(0.006)
	[-0.016;0.025]	[0.014;0.045]	[-0.019;0.025]	[-0.014;0.008]	[-0.001;0.003]	[0.015;0.031]

Appendix 2c – BVAR Estimates Corn

	Corn Return	Biofuel	WTI Crude	S&P 500	US IPI	Corn Volatility
Price Return-1	-0.129	0.002	-0.098	-0.061	-0.006	0.044
	(0.132)	(0.091)	(0.125)	(0.061)	(0.01)	(0.045)
	[-0.296;0.04]	[-0.114;0.117]	[-0.259;0.061]	[-0.139;0.016]	[-0.019;0.006]	[-0.014;0.102]
Biofuel-1	0.113	0.027	0.234	-0.054	0.012	-0.008
	(0.193)	(0.133)	(0.183)	(0.089)	(0.014)	(0.065)
	[-0.135;0.362]	[-0.144;0.194]	[-0.003;0.467]	[-0.167;0.06]	[-0.007;0.03]	[-0.091;0.074]
WTI Crude-1	-0.135	-0.040	0.100	-0.016	0.001	-0.004
	(0.097)	(0.067)	(0.094)	(0.046)	(0.007)	(0.033)
	[-0.259;-0.012]	[-0.126;0.045]	[-0.021;0.221]	[-0.075;0.044]	[-0.008;0.01]	[-0.046;0.039]
S&P 500-1	0.169	-0.015	0.443	0.257	0.000	0.055
	(0.2)	(0.14)	(0.193)	(0.095)	(0.015)	(0.069)
	[-0.091;0.423]	[-0.192;0.166]	[0.193;0.692]	[0.136;0.38]	[-0.019;0.02]	[-0.034;0.144]
US IPI-1	2.017	1.285	1.893	1.333	0.181	0.012
	(1.124)	(0.778)	(1.089)	(0.532)	(0.083)	(0.384)
	[0.593;3.48]	[0.292;2.288]	[0.498;3.296]	[0.651;2.013]	[0.073;0.287]	[-0.483;0.5]
Volatility-1	-0.103	-0.004	-0.128	0.004	0.031	0.898
	(0.251)	(0.173)	(0.241)	(0.119)	(0.019)	(0.086)
	[-0.425;0.218]	[-0.223;0.22]	[-0.44;0.182]	[-0.148;0.158]	[0.007;0.055]	[0.787;1.008]
Price Return-2	0.112	0.084	0.223	0.042	0.002	-0.046
	(0.122)	(0.086)	(0.119)	(0.058)	(0.009)	(0.042)
	[-0.045;0.268]	[-0.025;0.193]	[0.072;0.374]	[-0.033;0.117]	[-0.01;0.014]	[-0.099;0.009]
Biofuel-2	0.146	-0.028	-0.100	0.003	-0.014	-0.067
	(0.177)	(0.124)	(0.171)	(0.084)	(0.013)	(0.061)
	[-0.078;0.371]	[-0.189;0.13]	[-0.32;0.117]	[-0.104;0.11]	[-0.031;0.003]	[-0.146;0.01]
WTI Crude-2	-0.114	-0.002	-0.074	0.046	0.013	-0.035
	(0.092)	(0.065)	(0.089)	(0.043)	(0.007)	(0.032)
	[-0.234;0.004]	[-0.086;0.082]	[-0.187;0.04]	[-0.01;0.102]	[0.004;0.021]	[-0.076;0.006]
S&P 500-2	-0.203	-0.077	0.042	-0.153	0.034	-0.019
	(0.198)	(0.137)	(0.19)	(0.093)	(0.015)	(0.068)
	[-0.454;0.048]	[-0.25;0.097]	[-0.202;0.285]	[-0.274;-0.034]	[0.015;0.053]	[-0.105;0.069]
US IPI-2	1.720	1.186	0.523	0.854	0.223	-0.161
	(1.105)	(0.777)	(1.068)	(0.528)	(0.083)	(0.386)
	[0.291;3.136]	[0.19;2.177]	[-0.85;1.913]	[0.181;1.532]	[0.116;0.329]	[-0.659;0.337]
Volatility-2	0.099	0.110	0.141	0.032	-0.021	-0.195
	(0.247)	(0.175)	(0.235)	(0.118)	(0.019)	(0.085)
	[-0.219;0.415]	[-0.111;0.333]	[-0.157;0.448]	[-0.12;0.184]	[-0.044;0.003]	[-0.302;-0.085]
Intercept	0.008	-0.003	0.003	-0.003	-0.001	0.030
	(0.019)	(0.013)	(0.018)	(0.009)	(0.001)	(0.007)
	[-0.016;0.033]	[-0.02;0.013]	[-0.021;0.026]	[-0.015;0.008]	[-0.003;0.001]	[0.021;0.038]

Appendix 2d – BVAR Estimates Soybeans

	Soybeans Return	Biofuel	WTI Crude	S&P 500	US IPI	Soybeans Volatility
Price Return-1	-0.221	-0.142	0.132	0.002	-0.011	0.034
	(0.161)	(0.114)	(0.158)	(0.077)	(0.012)	(0.059)
	[-0.424;-0.014]	[-0.286;0.002]	[-0.071;0.334]	[-0.096;0.1]	[-0.027;0.005]	[-0.041;0.109]
Biofuel-1	0.164	0.197	-0.031	-0.121	0.016	-0.029
	(0.227)	(0.161)	(0.221)	(0.108)	(0.017)	(0.081)
	[-0.129;0.459]	[-0.009;0.402]	[-0.316;0.249]	[-0.257;0.017]	[-0.006;0.038]	[-0.133;0.074]
WTI Crude-1	-0.097	-0.077	0.113	-0.012	-0.001	0.031
	(0.097)	(0.069)	(0.096)	(0.047)	(0.007)	(0.035)
	[-0.221;0.025]	[-0.166;0.011]	[-0.011;0.236]	[-0.073;0.049]	[-0.01;0.009]	[-0.014;0.077]
S&P 500-1	0.283	0.012	0.394	0.235	0.000	-0.052
	(0.195)	(0.14)	(0.194)	(0.095)	(0.015)	(0.072)
	[0.032;0.53]	[-0.166;0.194]	[0.143;0.646]	[0.114;0.359]	[-0.019;0.019]	[-0.144;0.039]
US IPI-1	1.483	1.397	1.778	1.288	0.158	-0.739
	(1.07)	(0.762)	(1.067)	(0.521)	(0.082)	(0.389)
	[0.117;2.871]	[0.421;2.375]	[0.417;3.148]	[0.622;1.954]	[0.052;0.262]	[-1.238;-0.246]
Volatility-1	-0.244	-0.101	-0.085	0.031	0.000	0.876
	(0.252)	(0.18)	(0.25)	(0.122)	(0.019)	(0.092)
	[-0.57;0.082]	[-0.327;0.131]	[-0.408;0.235]	[-0.128;0.188]	[-0.025;0.025]	[0.757;0.994]
Price Return-2	0.275	0.106	-0.078	-0.045	0.001	-0.074
	(0.137)	(0.1)	(0.137)	(0.067)	(0.011)	(0.05)
	[0.099;0.449]	[-0.02;0.233]	[-0.251;0.098]	[-0.131;0.042]	[-0.012;0.015]	[-0.138;-0.01]
Biofuel-2	-0.185	-0.091	0.199	0.092	-0.014	0.024
	(0.193)	(0.139)	(0.192)	(0.094)	(0.015)	(0.071)
	[-0.429;0.062]	[-0.273;0.087]	[-0.045;0.444]	[-0.029;0.213]	[-0.033;0.005]	[-0.067;0.114]
WTI Crude-2	-0.003	0.009	-0.077	0.044	0.012	0.061
	(0.091)	(0.065)	(0.09)	(0.044)	(0.007)	(0.033)
	[-0.119;0.112]	[-0.074;0.092]	[-0.19;0.039]	[-0.012;0.1]	[0.004;0.021]	[0.019;0.104]
S&P 500-2	-0.125	-0.022	0.079	-0.141	0.040	0.029
	(0.193)	(0.137)	(0.19)	(0.094)	(0.015)	(0.07)
	[-0.371;0.123]	[-0.195;0.155]	[-0.163;0.322]	[-0.263;-0.021]	[0.021;0.059]	[-0.06;0.12]
US IPI-2	0.439	1.013	0.644	0.879	0.216	0.278
	(1.087)	(0.785)	(1.084)	(0.533)	(0.084)	(0.402)
	[-0.951;1.832]	[-0.004;2.02]	[-0.755;2.043]	[0.2;1.568]	[0.109;0.323]	[-0.239;0.796]
Volatility-2	0.055	-0.069	-0.092	-0.021	-0.002	-0.162
	(0.239)	(0.175)	(0.235)	(0.118)	(0.019)	(0.088)
	[-0.255;0.361]	[-0.292;0.157]	[-0.393;0.212]	[-0.172;0.132]	[-0.026;0.021]	[-0.274;-0.05]
Intercept	0.025	0.022	0.020	-0.001	0.001	0.025
	(0.017)	(0.012)	(0.017)	(0.008)	(0.001)	(0.006)
	[0.003;0.047]	[0.007;0.038]	[-0.002;0.042]	[-0.011;0.01]	[-0.001;0.002]	[0.017;0.033]

Appendix 2e – BVAR Estimates Sugar

	Sugar Return	Biofuel	WTI Crude	S&P 500	US IPI	Sugar Volatility
Price Return-1	0.132	0.043	-0.051	0.016	-0.002	0.011
	(0.093)	(0.062)	(0.086)	(0.042)	(0.007)	(0.035)
	[0.015;0.252]	[-0.037;0.122]	[-0.162;0.058]	[-0.037;0.069]	[-0.01;0.007]	[-0.034;0.056]
Biofuel-1	0.275	0.015	0.172	-0.128	0.005	-0.024
	(0.149)	(0.099)	(0.136)	(0.066)	(0.011)	(0.055)
	[0.083;0.468]	[-0.113;0.14]	[-0.004;0.347]	[-0.212;-0.044]	[-0.009;0.019]	[-0.093;0.046]
WTI Crude-1	-0.140	-0.057	0.079	-0.025	0.000	0.021
	(0.102)	(0.068)	(0.095)	(0.046)	(0.007)	(0.038)
	[-0.27;-0.013]	[-0.144;0.03]	[-0.042;0.201]	[-0.085;0.035]	[-0.009;0.009]	[-0.028;0.07]
S&P 500-1	-0.164	-0.026	0.354	0.234	-0.001	-0.054
	(0.207)	(0.139)	(0.193)	(0.096)	(0.015)	(0.078)
	[-0.433;0.098]	[-0.204;0.152]	[0.106;0.605]	[0.113;0.357]	[-0.02;0.019]	[-0.155;0.046]
US IPI-1	-0.305	1.237	1.942	1.316	0.147	-0.221
	(1.149)	(0.767)	(1.074)	(0.525)	(0.082)	(0.429)
	[-1.768;1.187]	[0.259;2.219]	[0.573;3.316]	[0.65;1.987]	[0.041;0.252]	[-0.774;0.325]
Volatility-1	-0.345	-0.050	0.052	0.031	0.012	0.830
	(0.221)	(0.147)	(0.204)	(0.101)	(0.016)	(0.083)
	[-0.627;-0.061]	[-0.238;0.141]	[-0.211;0.315]	[-0.097;0.162]	[-0.008;0.032]	[0.723;0.935]
Price Return-2	-0.124	-0.071	0.050	0.030	-0.004	0.012
	(0.089)	(0.06)	(0.083)	(0.041)	(0.007)	(0.034)
	[-0.239;-0.012]	[-0.149;0.006]	[-0.056;0.157]	[-0.023;0.082]	[-0.013;0.004]	[-0.031;0.055]
Biofuel-2	-0.074	0.078	0.100	0.023	-0.008	-0.153
	(0.146)	(0.098)	(0.135)	(0.066)	(0.01)	(0.055)
	[-0.261;0.113]	[-0.048;0.202]	[-0.074;0.273]	[-0.064;0.108]	[-0.021;0.006]	[-0.223;-0.083]
WTI Crude-2	0.125	0.002	-0.092	0.043	0.012	0.010
	(0.096)	(0.065)	(0.089)	(0.043)	(0.007)	(0.036)
	[0;0.248]	[-0.082;0.084]	[-0.205;0.022]	[-0.013;0.098]	[0.003;0.021]	[-0.037;0.056]
S&P 500-2	0.080	-0.073	0.072	-0.143	0.036	0.146
	(0.202)	(0.135)	(0.188)	(0.092)	(0.015)	(0.076)
	[-0.179;0.335]	[-0.247;0.102]	[-0.168;0.315]	[-0.261;-0.025]	[0.017;0.055]	[0.05;0.245]
US IPI-2	0.083	1.327	0.761	0.926	0.228	-0.053
	(1.147)	(0.78)	(1.075)	(0.53)	(0.083)	(0.439)
	[-1.389;1.543]	[0.323;2.324]	[-0.623;2.161]	[0.251;1.606]	[0.12;0.335]	[-0.615;0.516]
Volatility-2	0.148	-0.044	-0.296	-0.114	-0.014	-0.028
	(0.218)	(0.149)	(0.201)	(0.1)	(0.016)	(0.082)
	[-0.129;0.428]	[-0.235;0.148]	[-0.548;-0.037]	[-0.241;0.016]	[-0.034;0.007]	[-0.132;0.079]
Intercept	0.023	0.016	0.028	0.008	0.000	0.021
	(0.016)	(0.011)	(0.015)	(0.007)	(0.001)	(0.006)
	[0.003;0.044]	[0.003;0.03]	[0.009;0.047]	[-0.001;0.018]	[-0.001;0.002]	[0.013;0.029]

Appendix 2f – BVAR Estimates Wheat

	Wheat Return	Biofuel	WTI Crude	S&P 500	US IPI	Wheat Volatility
Price Return-1	0.006	0.033	-0.068	0.020	-0.003	-0.035
	(0.099)	(0.061)	(0.084)	(0.041)	(0.007)	(0.036)
	[-0.119;0.133]	[-0.046;0.111]	[-0.176;0.04]	[-0.032;0.073]	[-0.011;0.005]	[-0.08;0.011]
Biofuel-1	-0.061	0.007	0.206	-0.136	0.005	0.052
	(0.17)	(0.104)	(0.144)	(0.07)	(0.011)	(0.06)
	[-0.279;0.16]	[-0.127;0.139]	[0.019;0.389]	[-0.225;-0.046]	[-0.009;0.02]	[-0.024;0.127]
WTI Crude-1	-0.091	-0.045	0.070	-0.019	0.002	-0.053
	(0.111)	(0.068)	(0.095)	(0.047)	(0.007)	(0.04)
	[-0.232;0.048]	[-0.133;0.042]	[-0.052;0.193]	[-0.079;0.042]	[-0.007;0.012]	[-0.104;-0.002]
S&P 500-1	-0.290	-0.022	0.421	0.246	-0.001	0.007
	(0.223)	(0.139)	(0.192)	(0.095)	(0.015)	(0.081)
	[-0.579;-0.009]	[-0.199;0.157]	[0.173;0.669]	[0.125;0.369]	[-0.02;0.018]	[-0.097;0.111]
US IPI-1	1.625	1.231	1.823	1.273	0.152	0.314
	(1.245)	(0.77)	(1.078)	(0.526)	(0.082)	(0.446)
	[0.04;3.249]	[0.239;2.216]	[0.441;3.212]	[0.596;1.946]	[0.044;0.257]	[-0.263;0.887]
Volatility-1	0.073	0.121	0.310	0.170	-0.009	0.737
	(0.236)	(0.145)	(0.202)	(0.1)	(0.016)	(0.085)
	[-0.228;0.375]	[-0.063;0.31]	[0.05;0.568]	[0.042;0.298]	[-0.029;0.011]	[0.629;0.845]
Price Return-2	0.045	0.025	-0.027	0.050	0.003	-0.102
	(0.095)	(0.059)	(0.082)	(0.04)	(0.006)	(0.034)
	[-0.076;0.167]	[-0.051;0.101]	[-0.132;0.078]	[-0.001;0.102]	[-0.005;0.012]	[-0.146;-0.058]
Biofuel-2	-0.102	0.031	0.134	0.003	-0.014	0.085
	(0.165)	(0.102)	(0.142)	(0.069)	(0.011)	(0.059)
	[-0.312;0.111]	[-0.1;0.162]	[-0.047;0.314]	[-0.087;0.092]	[-0.028;0]	[0.01;0.161]
WTI Crude-2	-0.053	0.011	-0.056	0.068	0.013	-0.065
	(0.105)	(0.066)	(0.09)	(0.044)	(0.007)	(0.038)
	[-0.189;0.081]	[-0.074;0.095]	[-0.171;0.06]	[0.011;0.124]	[0.004;0.021]	[-0.114;-0.017]
S&P 500-2	-0.169	-0.050	0.079	-0.147	0.035	0.008
	(0.218)	(0.135)	(0.188)	(0.092)	(0.015)	(0.079)
	[-0.452;0.108]	[-0.223;0.122]	[-0.161;0.322]	[-0.265;-0.029]	[0.017;0.054]	[-0.092;0.109]
US IPI-2	2.599	1.116	0.650	0.768	0.214	-0.496
	(1.237)	(0.776)	(1.067)	(0.527)	(0.083)	(0.451)
	[1.01;4.175]	[0.124;2.104]	[-0.713;2.039]	[0.097;1.449]	[0.107;0.32]	[-1.075;0.087]
Volatility-2	0.043	-0.132	-0.231	-0.155	-0.003	0.052
	(0.234)	(0.148)	(0.2)	(0.1)	(0.016)	(0.085)
	[-0.257;0.342]	[-0.321;0.058]	[-0.484;0.027]	[-0.282;-0.026]	[-0.023;0.017]	[-0.055;0.162]
Intercept	-0.004	0.008	-0.004	-0.002	0.002	0.023
	(0.019)	(0.012)	(0.017)	(0.008)	(0.001)	(0.007)
	[-0.028;0.021]	[-0.007;0.023]	[-0.025;0.018]	[-0.012;0.009]	[0;0.003]	[0.014;0.032]